Progress Towards Understanding Fan Inlet Implications of Top-Mounted Propulsion

David Friedlander

NASA Glenn Research Center

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Outline

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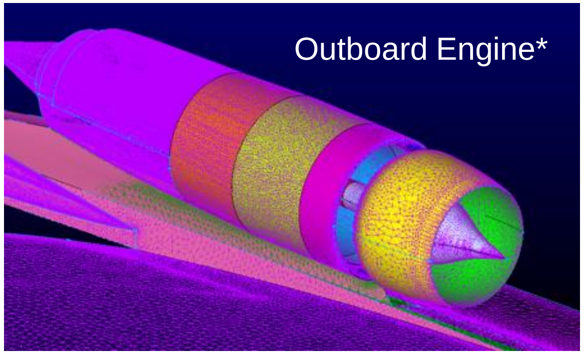
- Geometry Modifications
- Results
  - U-velocity contours
  - Iso-surfaces of separation
  - Inlet performance
- Conclusions/Future Work

Motivation

- There is an interest in top-mounting aircraft engines to take advantage of potential noise shielding benefits.
  - This is especially true for potential commercial supersonic transport aircraft.
- However, top-mounted propulsion might come at the cost of inlet performance due to ingesting boundary-layer flow.
- The goal of this work was to explore if top-mounted propulsion is feasible by using CFD. This includes looking at…
  - flow separation in/around the top-mounted engines.
  - inlet performance.
  - acoustic implications.

Overview

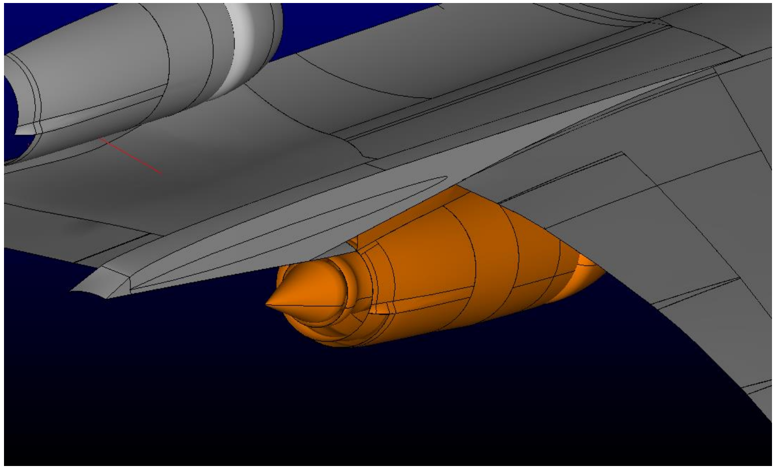
- Geometry:
  - LM1044-3b airframe
  - Inlets configured for take-off (i.e. aux. doors open)
  - Three-stream nozzles configured for take-off
  - Outboard engines mounted on-top of the wing
- Unstructured grid generated with Pointwise:
  - 35.7 million nodes
  - Only half geometry modeled due to symmetry
- Take-off flow conditions:
  - Inlet: m_dot = 860lb_m/s, M_{fan} = 0.55
  - Ambient: M = 0.3, p = 14.3psi, T = 530°R, α = 0°, 8°
- Turbulence model:
  - SST
- Flow Solver:
  - FUN3D V13.1



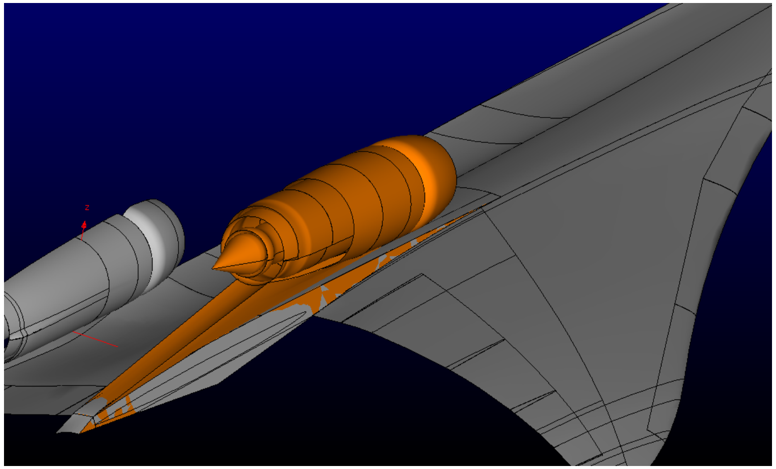
*Center engine hidden for clarity

LM1044-3b Geometry Modifications

- The outboard engine was moved above the wing to the location that was run in the GE NRA simulations.
- A simple pylon was created to connect the engine to the airframe as the geometry of the pylon used in the GE NRA simulations was not available.



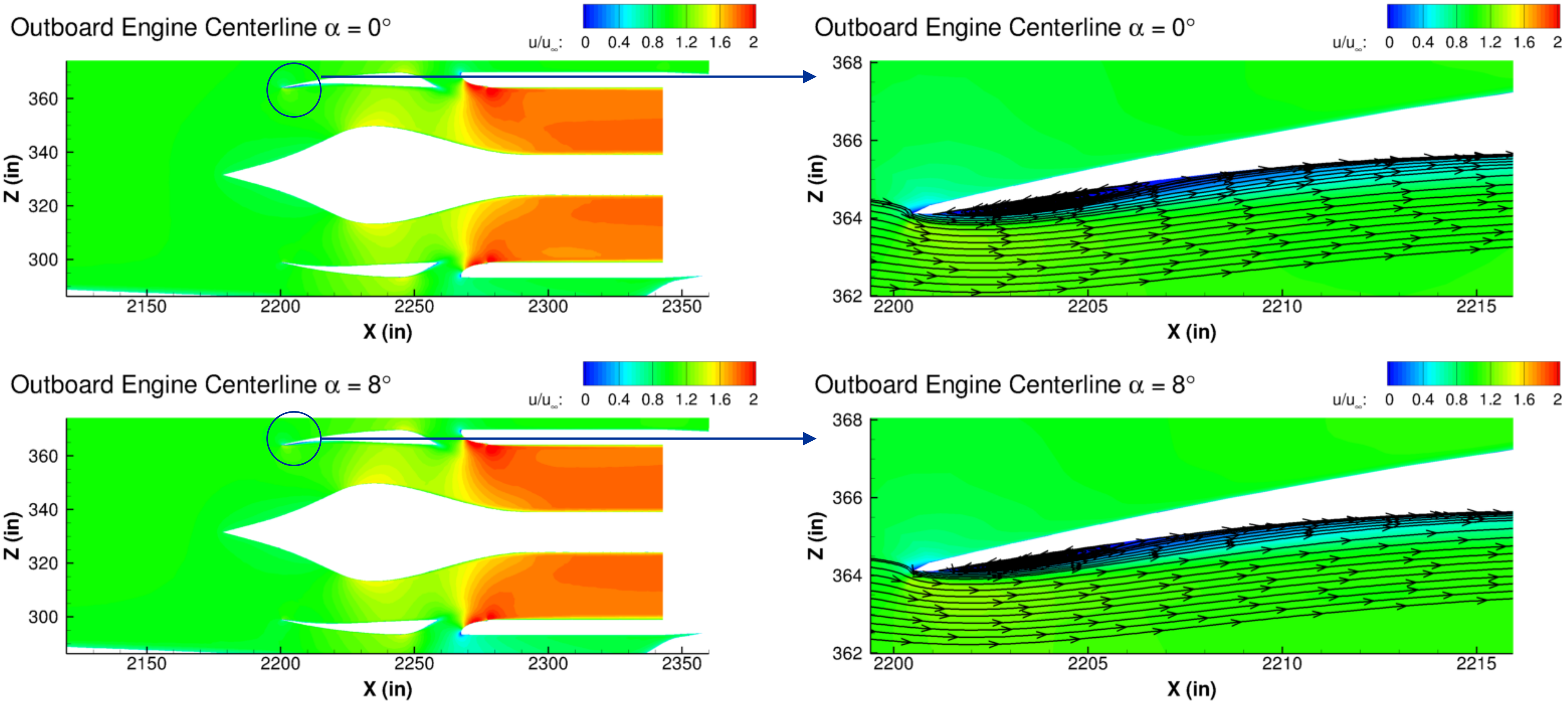
Original Location



Modified Location

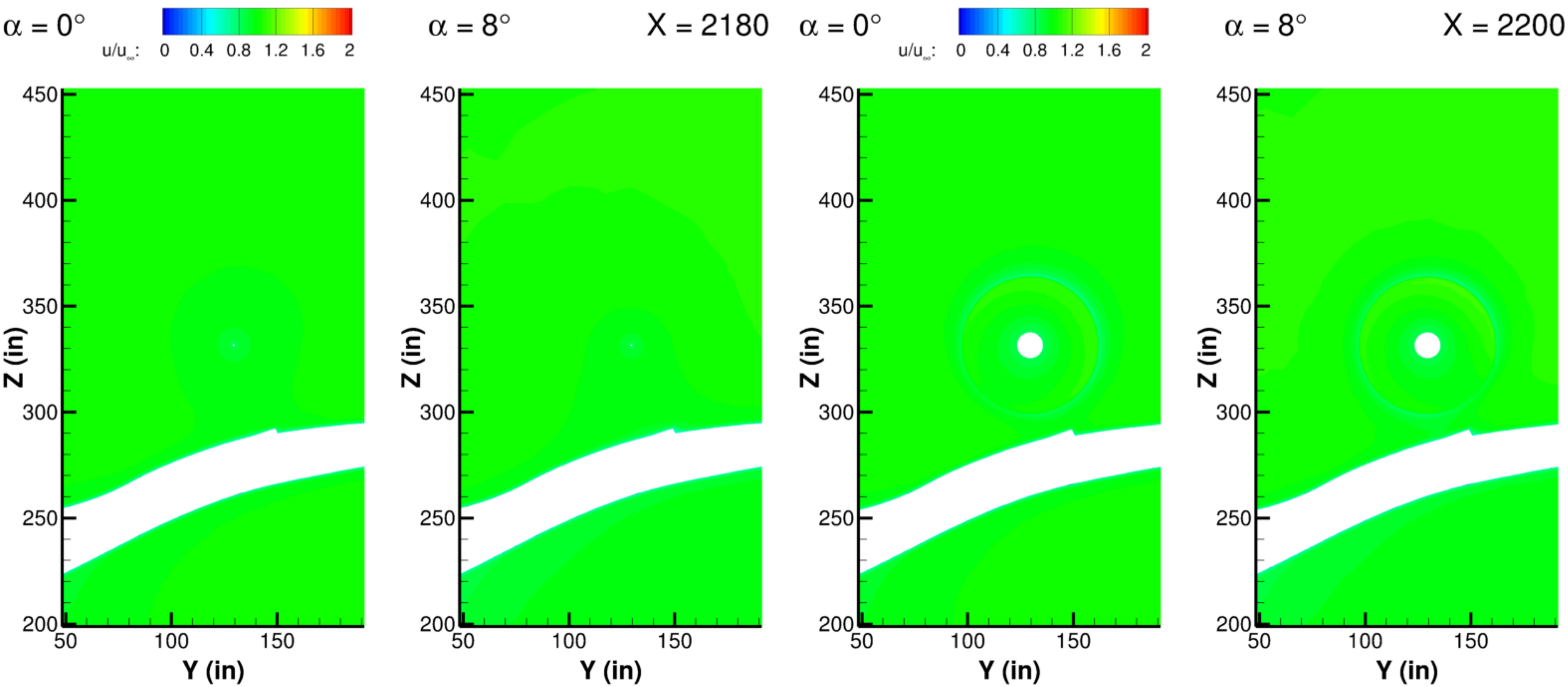
Results

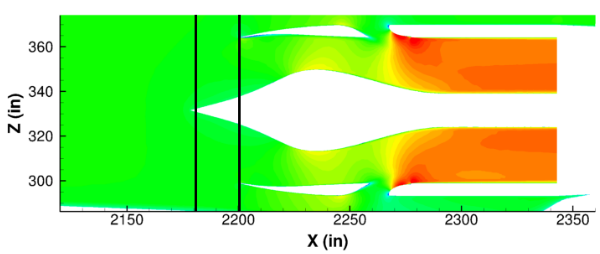
Outboard Engine Centerline



There is a little bit of separation in the inside of the top nacelle tip at both 0° and 8° angle of attack.

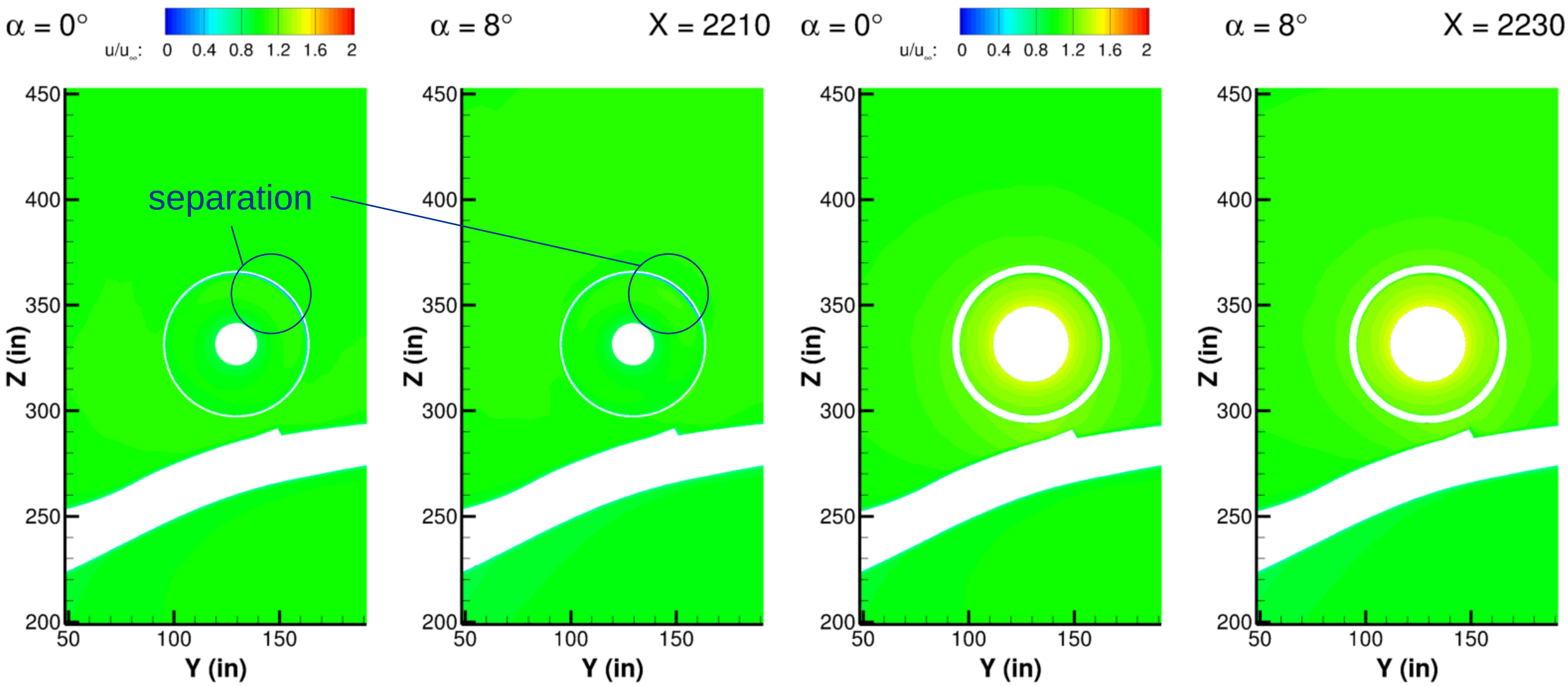
Inlet Spike and Nacelle Tips

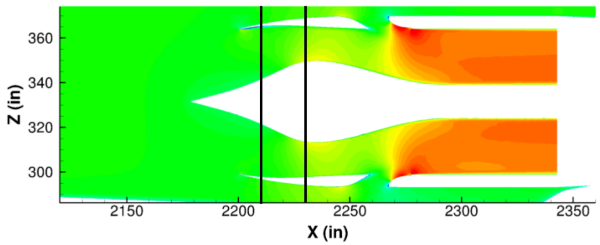




Little difference in the flow field between 0° and 8° angle of attack.

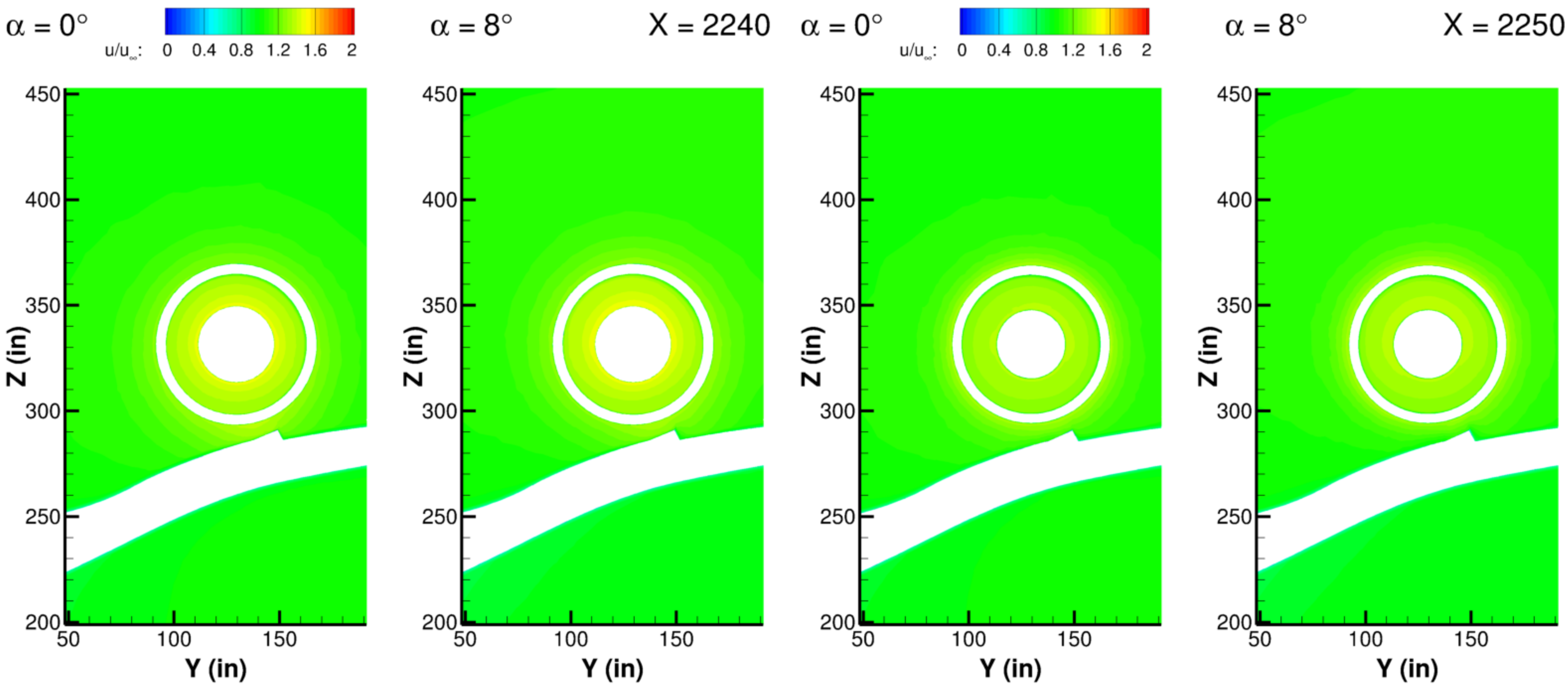
Inlet (Upstream of Aux. Doors)

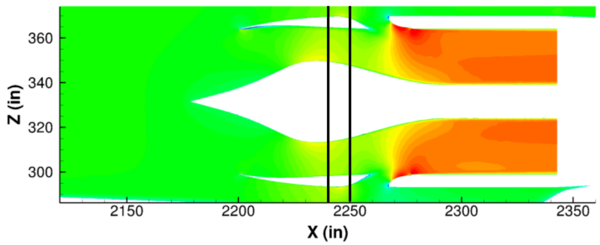




Little difference in the flow field between 0° and 8° angle of attack. Note there is a small separation inside the nacelle at x = 2210in.

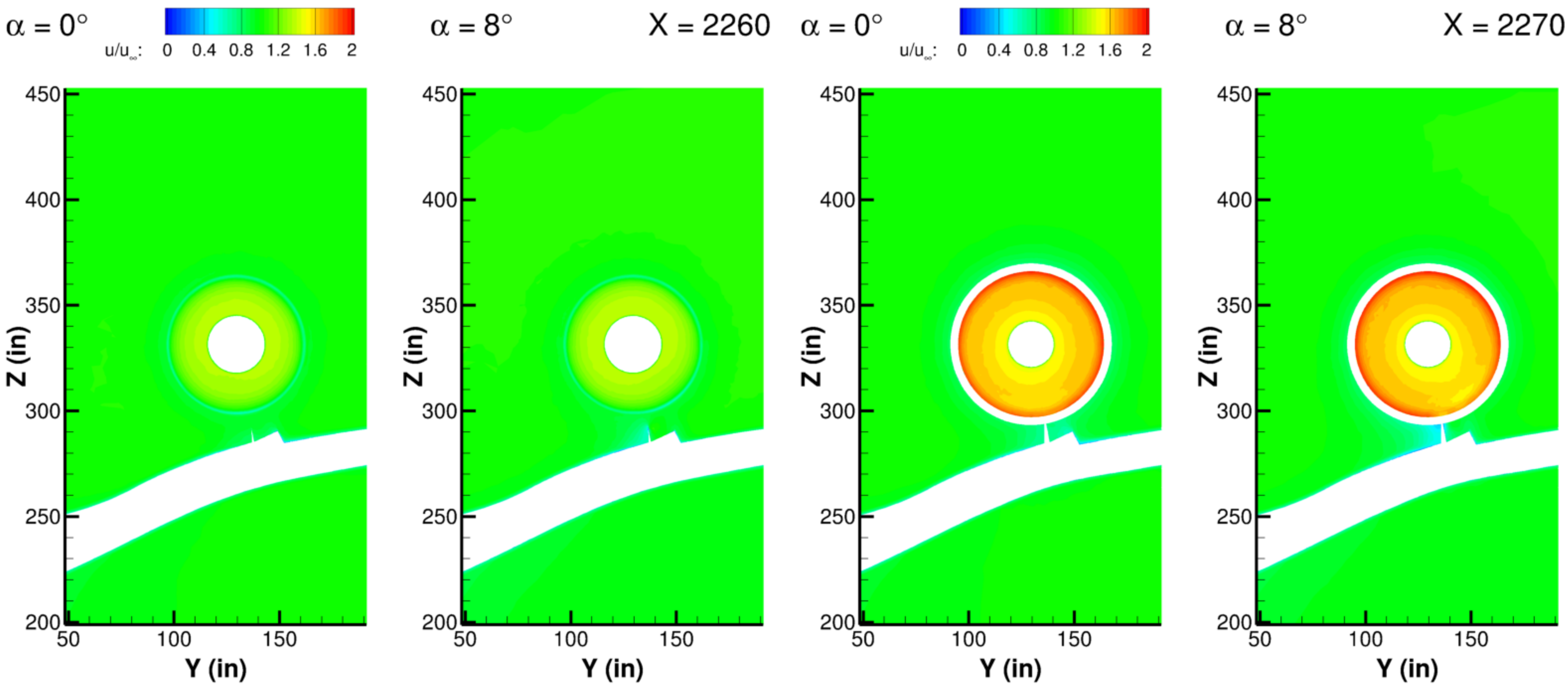
Inlet (Upstream of Aux. Doors)

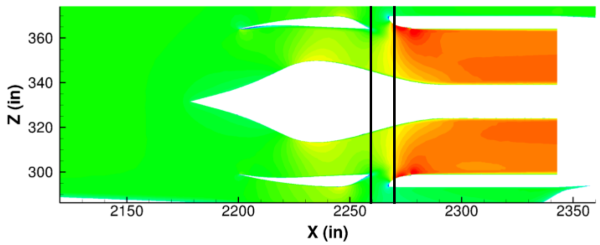




Little difference in the flow field between 0° and 8° angle of attack.

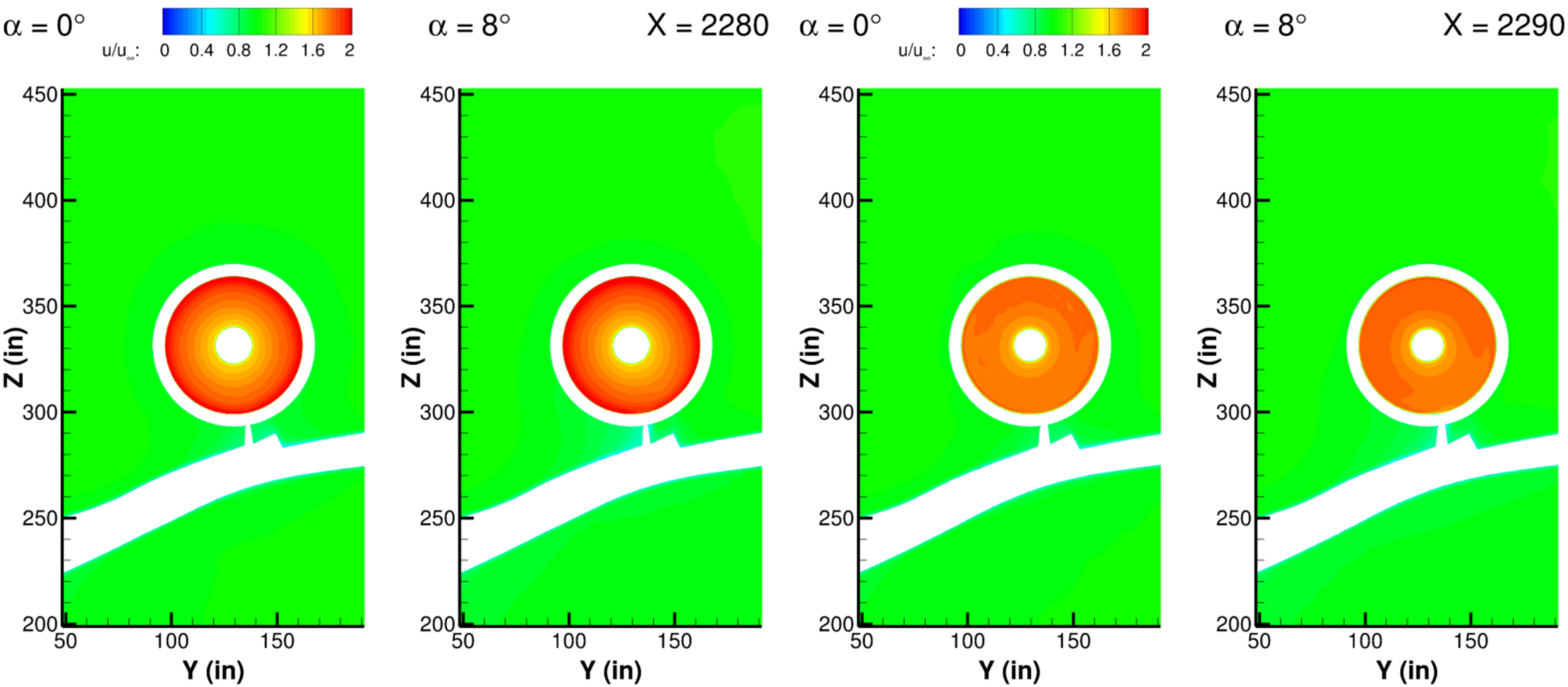
Aux. Doors

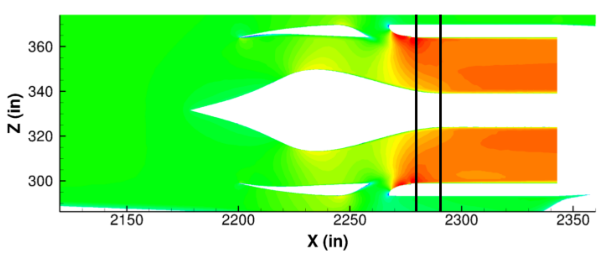




U-velocity deficit shifted slightly outboard at x = 2270in at 8° compared to 0° angle of attack.

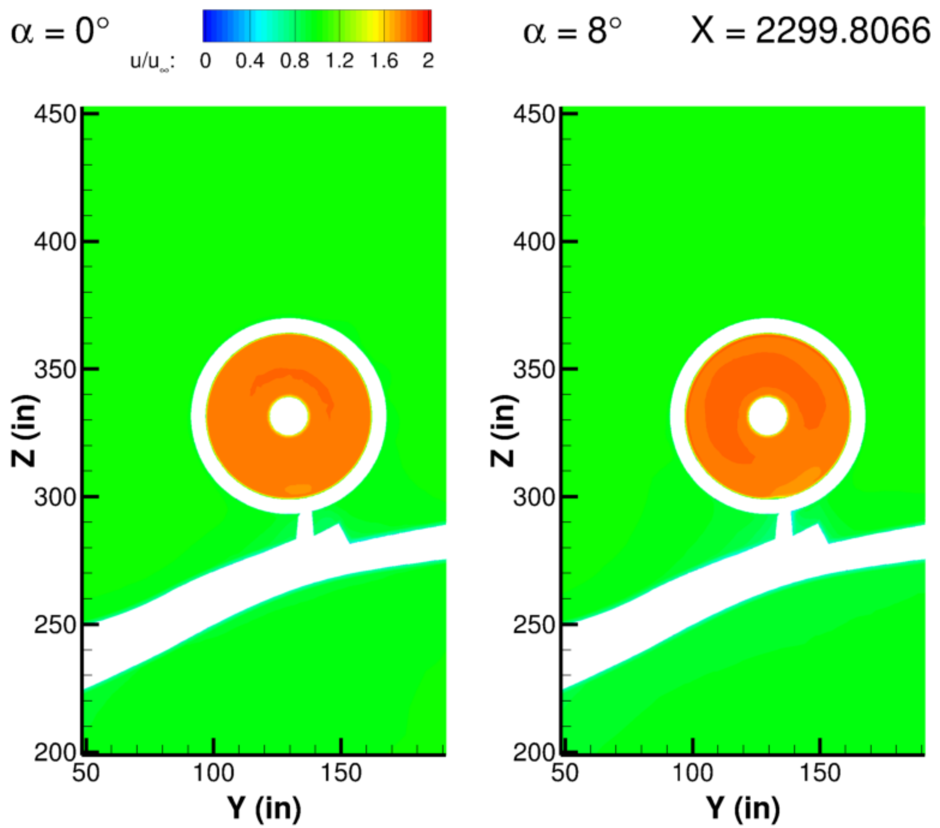
Inlet (Downstream of Aux. Doors)

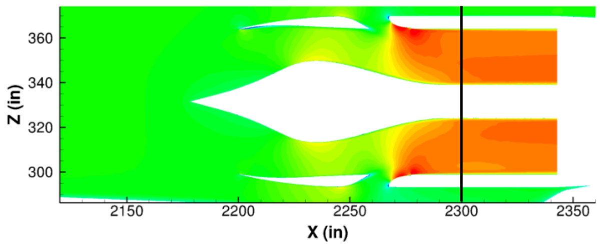




More higher speed flow in the inlet at x = 2290in at 8° compared to 0° angle of attack.

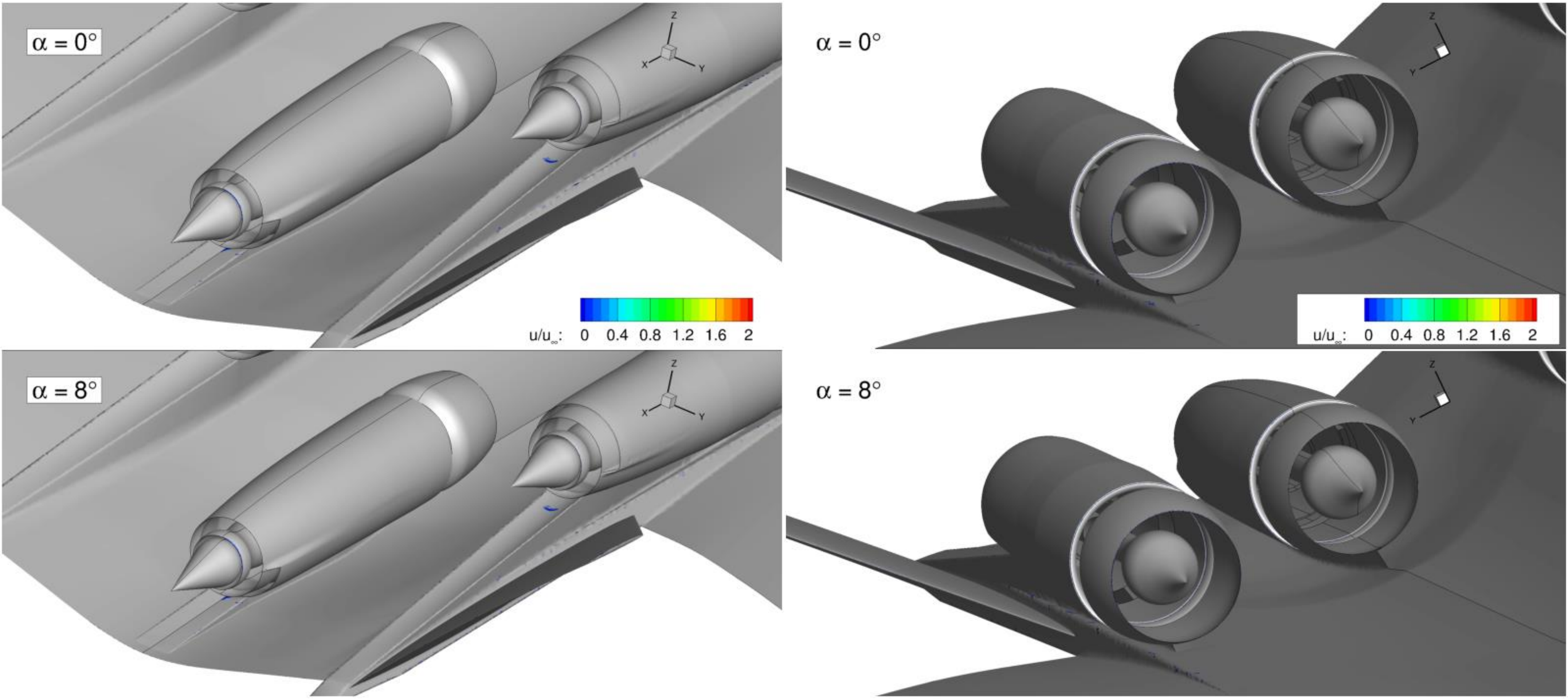
AIP





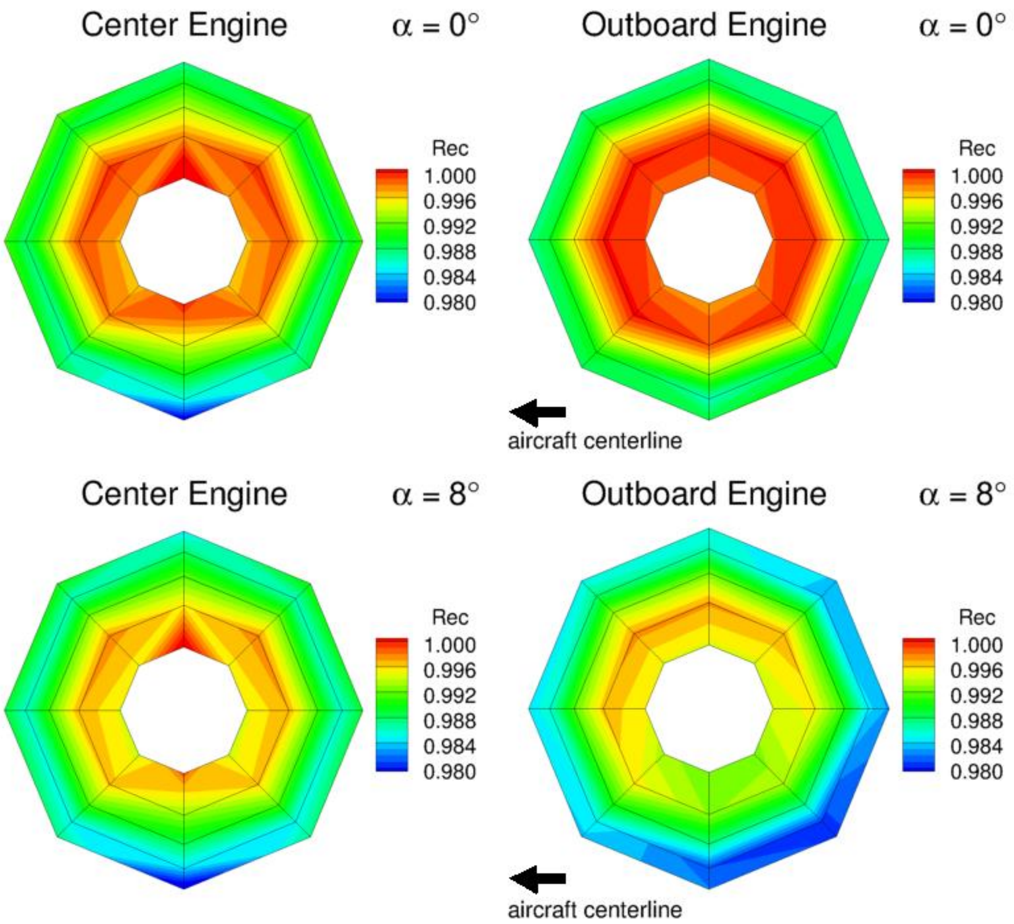
More higher speed flow in the inlet at 8° compared to 0° angle of attack.

Iso-Surface
(U-Velocity = -0.0001 ft/s)



There is very little separation external of the inlets and nozzles at 0° and 8° angle of attack.

Total Pressure Recovery Contours



Both the center and outboard engines show less total pressure recovery at 8° compared to 0° angle of attack.

Outboard Engine Inlet Performance

LM1044-3b : Underwing Configuration
LM1044-TMP : Top-Mounted Configuration

	α = 0°		α = 8°
	LM1044-3b[1]	LM1044-TMP	LM1044-TMP
Total Pressure Recovery (Rec)	0.993	0.993	0.990
Circumferential Inlet Distortion (IDC)	0.01216	0.00159	0.00315
Radial Inlet Distortion (IDR)	0.00610	0.00592	0.00612

- Total pressure recoveries are identical for the top-mounted and underwing configurations while both circumferential and radial distortion are lower for the top-mounted configuration at 0° angle of attack.
- Both the circumferential and radial distortion increases at the higher angle of attack.

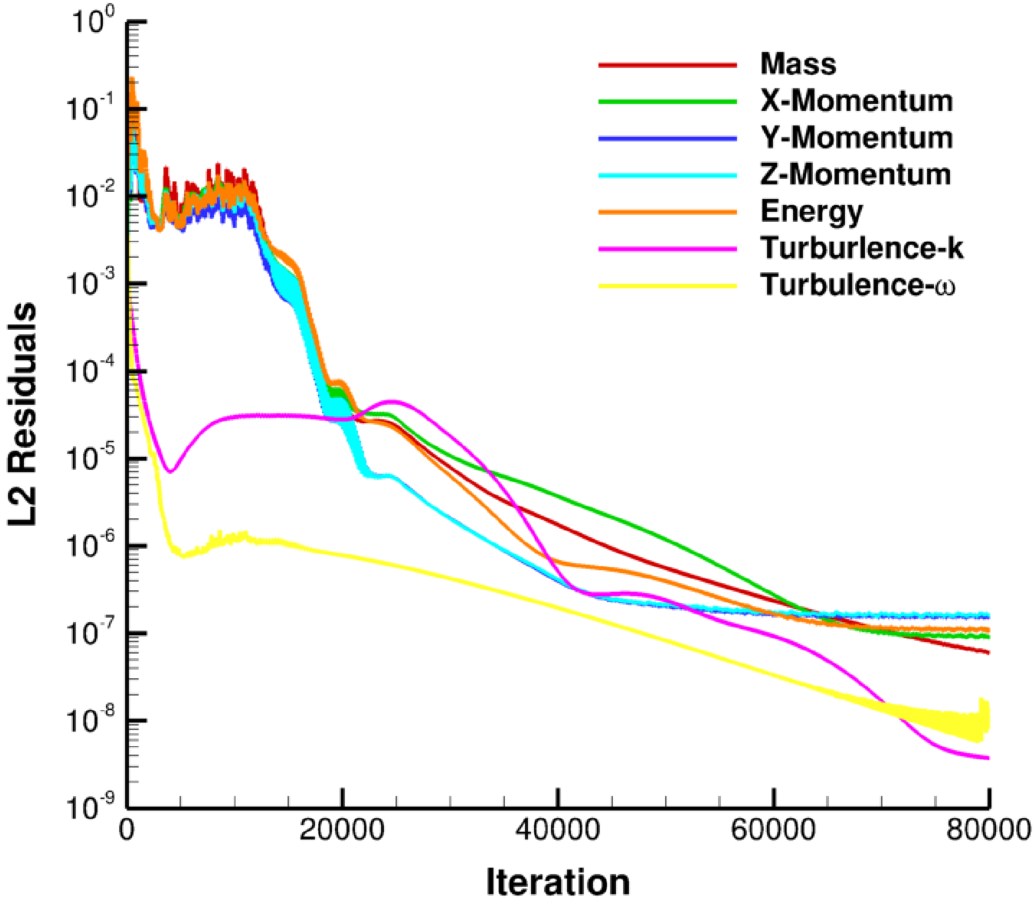
[1]Dippold, V. and Friedlander, D., “Relating a Jet-Surface Interaction Experiment to a Commercial Supersonic Transport Aircraft Using Numerical Simulations,” AIAA 2017-1853, January 2017.

Conclusions/Future Work

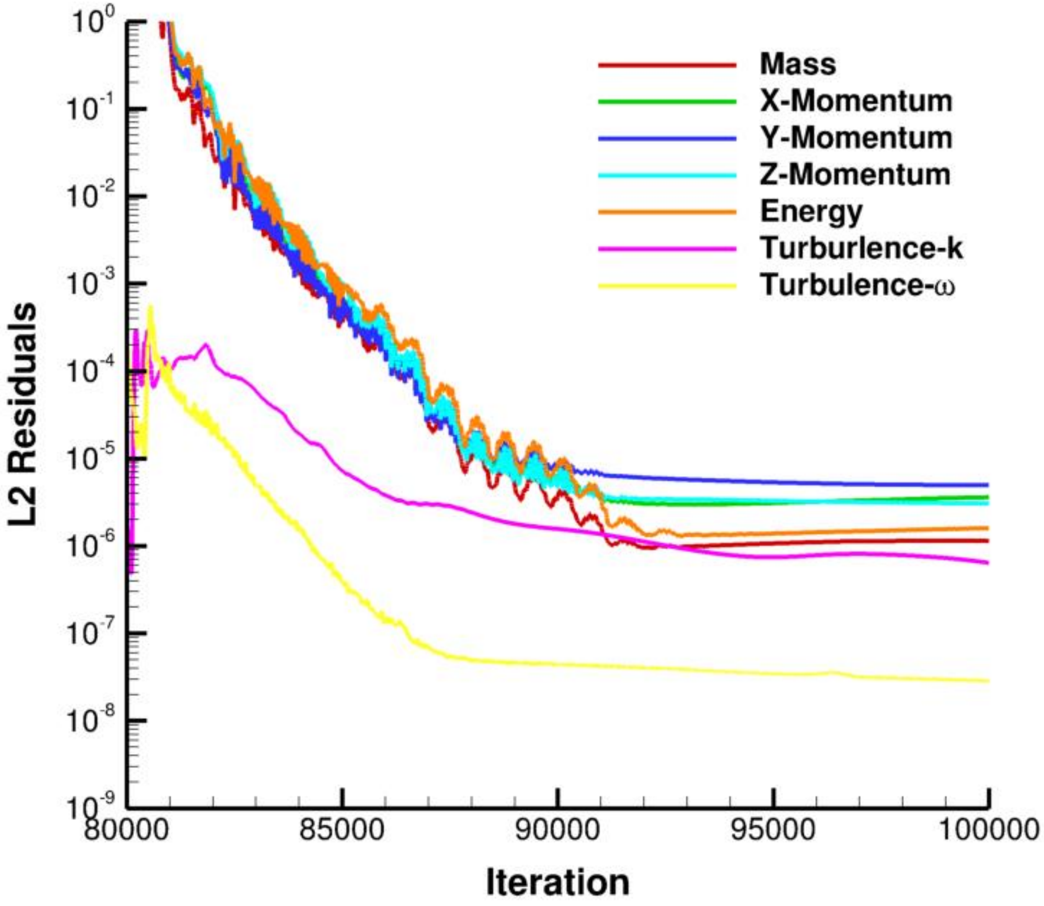
- Very little separated flow in and around the outboard engine inlets, reducing the risk of potential noise sources.
- No inlet performance penalty by mounting the outboard engines above wing compared to below the wing.
- Future work includes working with researchers in the Acoustics Branch to determine the potential acoustic impact of this top-mounted the propulsion system.

Backup Slides

Convergence History (α = 0°)

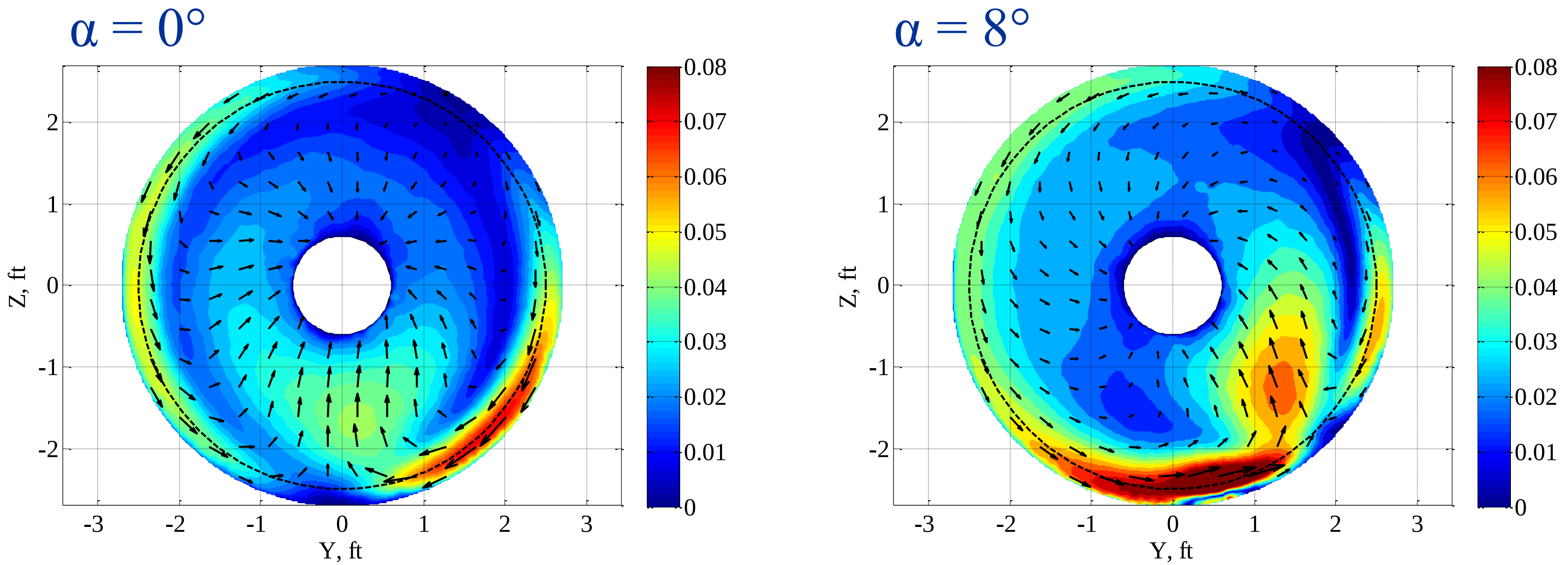


Convergence History* (α = 8°)



*Initial solution from converged α = 0° solution.

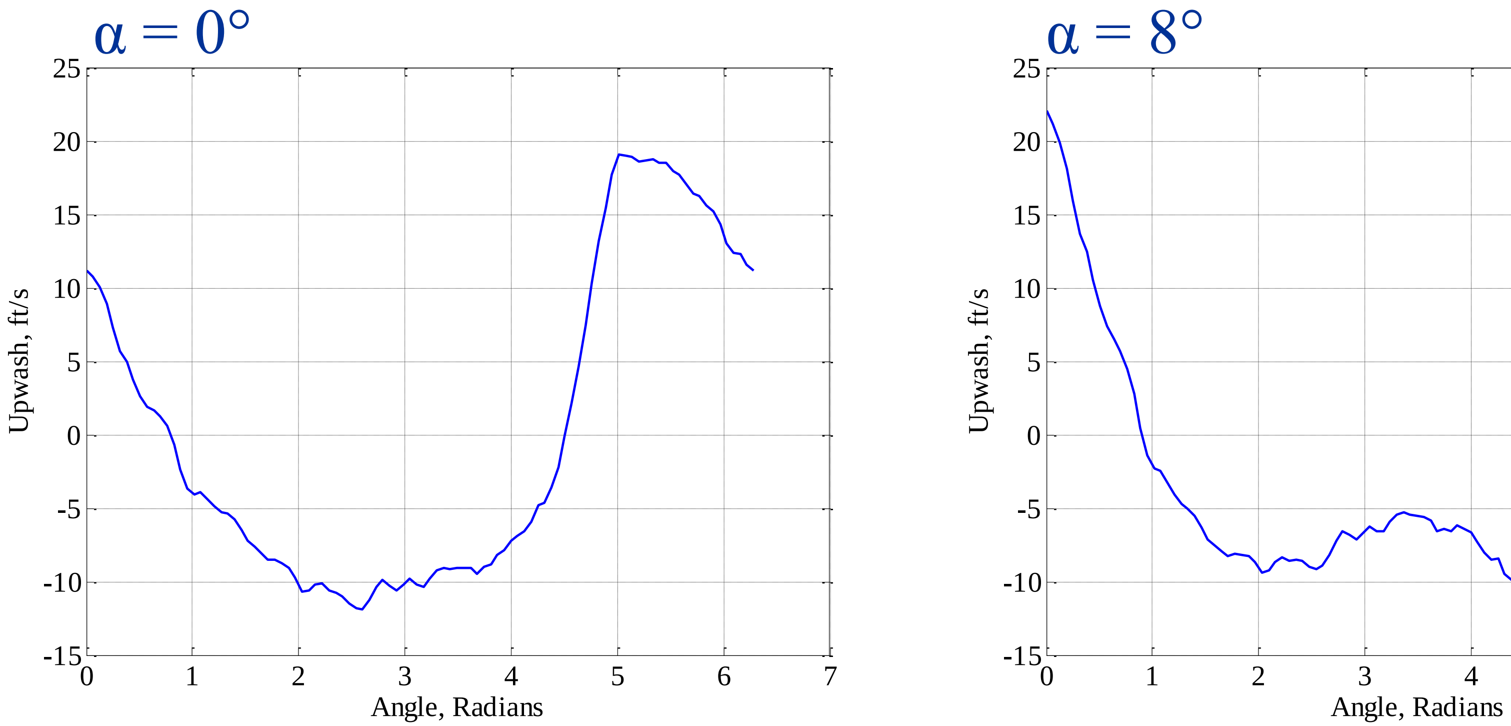
In-Plane Velocity Magnitude*



Plots are non-dimensionalized by the axial velocity.

*provided by D. Stephens

Upwash*



Plots show the upwash from the dotted line circle at 93% of the tip radius (assumes 1400ft/s tip speed[2])

[2]Stephens, D. B., "Fan Noise for a Concept Commercial Supersonic Transport," AIAA 2017-4635, July 2017.

*provided by D. Stephens